The subject invention results from the realization that, in a feedback system in which the output closely tracks the input, the error signal is small, and so rather than sample both the input and feedback signals before taking the difference to create the error signal, it is better to form the error signal with a continuous-time (non-sampling) circuit followed by a gain stage and then sample this amplified error signal using a switched-capacitor circuit. This arrangement causes the input-referenced switch thermal noise to be reduced by the amount of the gain used in the error path. The amount of gain that can be used in the error path depends on how closely the output tracks the input; it is desirable to make this gain as large as possible without causing the error signal to exceed the supply voltage.

Vallancourt shows a sample and hold circuit that can be powered with a low voltage supply, e.g., of about 1 volt. Referring to Fig. 3, to which the Examiner cites, Vallancourt shows a sample and hold circuit that includes an operational amplifier OA4 and a number of switches including switches M5 and M6. The operation of switches M5 and M6 is described at col. 8, lines 29-41. As described in this passage, for a range of input voltages from 0 to 0.5 volts, switch M5 is open and $V_{out}=V_{in}$. For inputs from 0.8 volts to 1.0 volts, switch M6 is open and once again $V_{out}=V_{in}$. Thus, when either M5 or M6 is open, the operational amplifier OA4 does not provide any voltage gain.

For the range of input voltages when V_{in} is in between 0.5 volts and 0.8 volts, both switches M5 and M6 are closed and OA4 fails to act as a difference amplifier as the Examiner asserts. When both switches M5 and M6 are closed, the operational amplifier OA4 is configured as an amplifier but does not act as a difference amplifier as can be seen from Table I and the accompanying text at column B, line 60 to column 9, line 3. Referring to Table I, OA4 does not act as a difference amplifier because V_O does not equal V_{IN}-V_{OUT} as would be required

by a difference amplifier (V_O is essentially V_{CH} in Table I). For example, V_O=0.29v when both V_{IN} and V_{OUT} are 0.79v such that $V_O \neq V_{IN}-V_{OUT}$. That OA4 is not a difference amplifier is further supported by the description in Vallancourt at column 8, lines 60-64 which is states that when V_{IN} is in the range of 0.5-0.8v, then $V_O=V_{IN}$-0.5v (0.5v is the voltage across Capacitor V_{CS}), rather than $V_O=V_{IN}-V_{OUT}$ as required by a difference amplifier. From this analysis, it is clear that at all times the operational amplifier is either not used for voltage gain or not used as a difference amplifier. Thus, Vallancourt does not show an input circuit for providing a signal representative of a difference and including means for amplifying a difference signal before it is submitted to a filter circuit to reduce input-referred thermal noise by a factor of approximately the gain of the amplification as claimed in the subject invention.

Additionally, Vallancourt clearly fails to disclose a circuit for reducing input-referred thermal noise by a factor of approximately the gain of the amplification. In fact, Vallancourt fails to disclose thermal noise reduction whatsoever.

In contrast to Vallancourt, claim 1 of the subject invention recites: "A filter system with reduced switch thermal noise comprising: an input circuit for receiving an input signal and a feedback signal and providing a signal representative of the difference; a filter circuit including at least an input sampling capacitor and switch which introduces thermal noise error; a feedback circuit, responsive to said filter circuit, for delivering to said input circuit said feedback signal; and said input circuit including means for amplifying said difference signal, before it is submitted to said filter circuit to reduce the input-referred thermal noise by a factor of approximately the gain of the amplification." Clearly Vallancourt fails to disclose or suggest this claimed structure.

Claim 4 of the subject invention recites: "ΣΔ modulator with a filter system having reduced switch thermal noise comprising: an input circuit for receiving an input signal and a

quantized feedback signal and providing a signal representative of the difference; a filter circuit including at least an input sampling capacitor and switch which introduces thermal noise error; a quantizer circuit for quantizing the output of said filter circuit; a feedback circuit, responsive to said quantizer circuit, for delivering to said input circuit said quantized feedback signal; and said input circuit including means for amplifying said difference signal, before it is submitted to said filter circuit to reduce the input-referred thermal noise by a factor of approximately the gain of the amplification." Vallancourt does also does not disclose such a structure. For example, in addition to the deficiencies of the Vallancourt disclosure described above, Vallancourt also does not disclose a $\Sigma\Delta$ modulator.

Additionally, Vallancourt does not disclose the subject matter of claims 7 and 9, which recite similar structure to claims 1 and 4, respectively, that distinguish over the disclosure of Vallancourt.

Accordingly, Vallancourt does not disclose or suggest the structure of the claims of the subject application. Applicants respectfully request that the Examiner remove the rejections under 35 U.S.C. §102(e).

Claims 2, 4, 8, and 10 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Vallancourt. Claims 2, 8, and 10, however, each depend from one of the independent claims 1, 4, or 9 and thus incorporate the features of one of the independent claims and also include one or more additional features that distinguish over Vallancourt. As such, claims 2, 8, and 10 are patentable for at least the reasons stated above. Claim 4 is an independent claim and, as noted above, has features that clearly distinguish the subject invention over Vallancourt.

The Examiner states in the office action dated July 2, 2002 that "it would have been [an] obvious matter of design choice to vary the amplifier gain in Vallancourt's apparatus to

meet different performance requirements since applicant has not disclosed the claimed gain solved any stated problems or are for any particular purposes." The application clearly discloses, however, that the gain of the amplification of the input circuit provides the benefits of the subject application. When the error signal is followed by a gain stage, as disclosed in the subject invention, the arrangement causes the input-referenced switched thermal noise to be reduced by the amount of the gain used in the error path (see application at page 4, lines 9-17). Thus, the subject invention clearly distinguishes over the apparatus shown in Vallancourt because Vallancourt's input circuit does not include an amplifier that provides any voltage gain.

Accordingly, Vallancourt does not make obvious the claims of the subject invention. Applicants respectfully request that the Examiner withdraw the rejections under U.S.C. §103(a).

Each of the Examiner's rejections has been addressed or traversed. Accordingly, it is respectfully submitted that the application is in condition for allowance. Early and favorable action is respectfully requested.

If for any reason this Response is found to be incomplete, or if at any time it appears that a telephone conference with counsel would help advance prosecution, please telephone the undersigned or his associates, collect in Waltham, Massachusetts, (781)890-5678.

Respectfully submitted,

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